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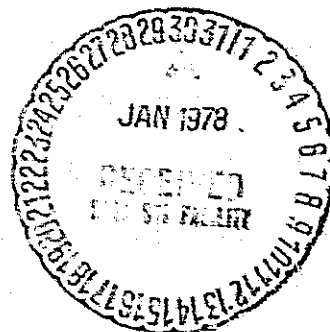
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NASA CR-150480

AN EVALUATION OF CODING METHODOLOGIES FOR POTENTIAL
USE IN THE ALABAMA RESOURCE INFORMATION SYSTEM (ARIS) -
- TRANSPORTATION STUDY FOR THE STATE OF ALABAMA

December 1977



NASA - George C. Marshall Space Flight Center
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16. ABSTRACT This report describes a study of digitizing the transportation arteries, airports, and dock facilities of Alabama and placing them in a computerized format compatible with the Alabama Resource Information System (ARIS). The five county region of the Top of Alabama Regional Council of Governments (TARCOG) was selected as the pilot study area. The research focused on the following objectives: (1) The digitization of the TARCOG area transportation networks consisting of highways, railroads, and waterways; (2) the digitization of airports and dock facilities within the TARCOG area; (3) evaluation of the time required to digitize by the following methods: (a) manual, (b) Telereadex 29 with film reading and digitizing system, and (c) digitizing tablets. A method for digitizing and storing information from the U. T. M. grid cell base which was compatible with the ARIS was developed and tested. The transportation arteries, airports, and docks in the study area were digitized and the data stored. The manual method of digitizing was shown to be best for small amounts of data, while the graphic input from the digitizing tablets would be the best approach for entering the large amounts of data required for an entire state. Editor's Note - Use of trade names or names of manufacturers in this report does not constitute an official endorsement of such products or manufacturers, either expressed or implied, by the National Aeronautics and Space Administration or any other agency of the United States government.			
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CHAPTER I

INTRODUCTION

The research activities reported herein are a continuation of the program initiated in 1971 at Alabama A & M University under the sponsorship of the National Aeronautics and Space Administration (NASA), with current research cosponsored by the Alabama Development Office (ADO).

Planet Earth has entered a new era - one marked by a growing awareness that the resources of the planet are limited; this in the face of an ever-increasing demand for their use. Man has begun to appreciate the need for research aimed at making the best use of the limited resources within our ecosphere. With the development of computers comes the ability to obtain, store and retrieve enormous amounts of data for any land, water or atmospheric phenomena of interest.

Many national, state and local organizations have become increasingly aware of the advantages of this technology and have begun using computerized systems to monitor the resources within their regions. The Alabama Development Office is one of the interested users. As the cosponsor of contracts with Auburn University, they have developed a data storage bank of the resources within the State of Alabama, the Alabama Resource Information System (ARIS). The functional components of this system are:

- 1) Data bases
- 2) Data gathering
- 3) Information processing aids and data base manipulation programs

A preponderance of the data presently in the system is in grid cell format. The particular grids used correspond to those of the U. T. M. grid systems. The ARIS system has progressed to the point where the developers are ready to input the transportation arteries of the state into the system.

The Alabama Development Office and NASA have cosponsored a research grant at Alabama A & M University for the development and testing methods of capturing and retrieving transportation information in a format compatible with the ARIS system. The targets of interest were:

- 1) Highways
- 2) Railroads
- 3) Waterways
- 4) Airports, and
- 5) Dock facilities.

An acceptable procedure has been developed and tested and a discussion of that system is presented in the subsequent chapters.

CHAPTER II

PROGRAM OBJECTIVES AND PLAN OF WORK

OBJECTIVES

The Department of Natural Resource and Environmental Studies, Alabama A & M University has addressed the problem of digitizing the transportation arteries of Alabama and placing them in a computerized format compatible with the Alabama Resource Information System (ARIS). The five-county area under the auspices of the Top of Alabama Regional Council of Governments (TARCOG) was selected as the study area. The research focused on the following specific objectives:

- 1) The digitization of TARCOG area transportation networks consisting of highways, railroads and waterways.
- 2) The digitization of airports and dock facilities within the TARCOG area.
- 3) Evaluation of time required when digitizing with one of the following methods: a. Manual, b. Telereadex 29 with Film Reading and Digitizing System and c. Digitizing Tablets.

PLAN OF WORK

The plan of work is presented in Fig. 1. The initial step was the acquisition of a suitable data base. Once the desired data had been collected a classification peculiar to the data type was formulated. Concurrent with the encoding of the data was the development of the software that would perform the necessary storage and retrieval manipulations of the test data. Upon completion of those processes the encoded data was processed such that it could be stored, updated and retrieved at any future time. A brief discussion of each stage of development is given here.

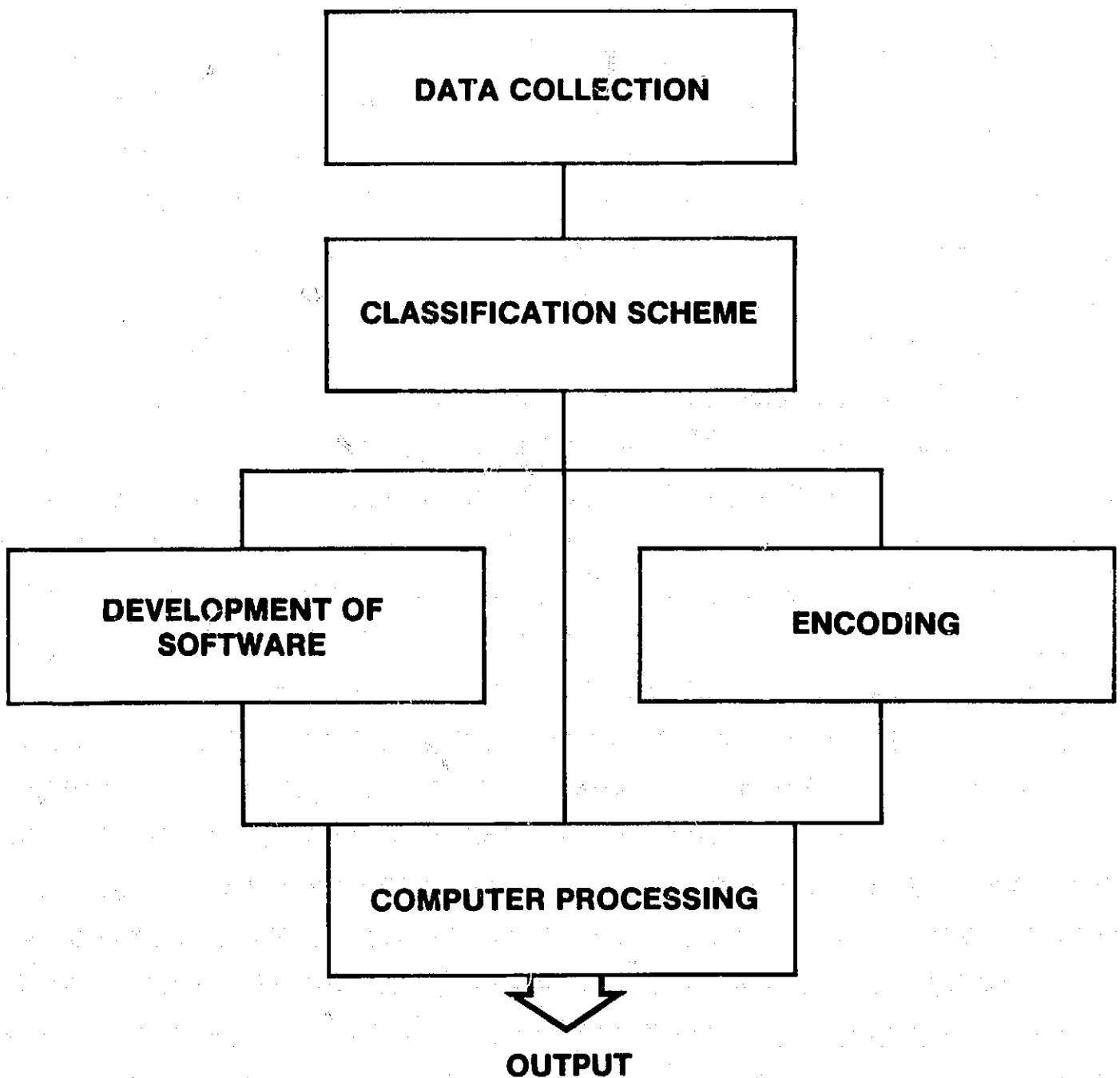


FIGURE 1. Plan of work for the digitization of transportational arteries.

A. Data Collection

Current information regarding the location of the transport system within the target area was provided by the local TARCOG office. This data had been color-coded onto State Highway maps (2.5 cm = 4 Km) over which 4-kilometer square grids were superimposed. This scale was used to facilitate encoding of test material. The encoded data was bounded by the following grid coordinates; north/south (3970,000-3785,000) and east/west (630,000-480,000) [Fig. 2]. The U. T. M. grid system is the same grid system used by ARIS.

B. Classification Scheme

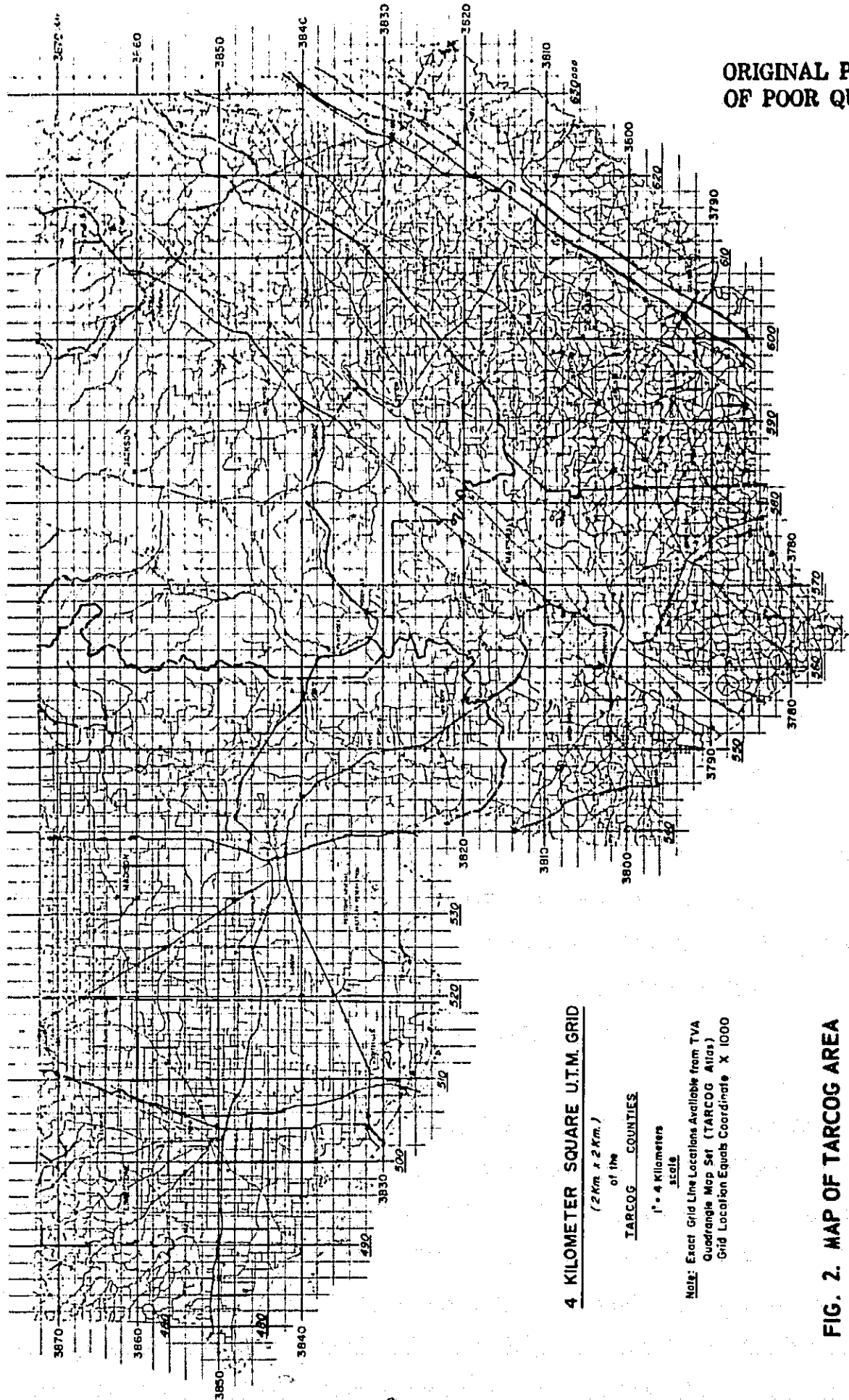
From the raw data it was found that all of the data could be represented by ten classes (Table 1).

Table 1. Classification Scheme

Class Name	Coding System
<u>Highways</u>	
Principal Arterial	1
Minor Arterial	2
Major Collection	3
<u>Navigable Waterways</u>	4
<u>Dock Facilities</u>	5
<u>Airports</u>	
Basic Utility	6
General Utility	7
Basic Transport	8
Air Carrier	9
<u>Railroads</u>	0

The numbers appearing in the columns labeled "Coding Symbol" are the codes that were used throughout the digitization process. The following are descriptions/examples of the above-mentioned classes.

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4 KILOMETER SQUARE UTM GRID

(2 Km x 2 Km.)

of the

TARCOG COUNTRIES

1" = 4 Kilometers
scale

Note: Exact Grid Line Locations Available from TVA
Quadrangle Map Set (TARCOG Atlas)
Grid Location Equals Coordinate X 1000

FIG. 2. MAP OF TARCOG AREA

Highways

Principal Arterial - Major streets and roads used for high volume traffic movement to, within and through the region.

Minor Arterial - Major streets and roads used for high volume traffic, primarily from the other areas of the region toward urbanized areas rather than serving traffic primarily through the region to other areas.

Major Collectors - Major streets and roads used for traffic of moderate-to-fast speeds and relatively high traffic volumes between communities of moderate size and between major local centers of employment, recreation, shopping, residence and rural areas.

Navigable Waterways

Rivers or streams that are of sufficient size to accommodate barge traffic.

Dock Facilities

Facilities for public and private use, primarily oriented to commercial and industrial barge traffic.

Airports

These airports are classified according to the Federal Aviation Administration (FAA) National Airport Plan.

Basic Utility - a. Hazel Green Airport, b. Mills Airport and c. Goose Pond Airport.

General Utility - a. Meridianville Airport, b. Guntersville Municipal Airport, c. Stevenson Municipal Airport, d. Fort Payne Municipal Airport.

Basic Transport - a. Pryor Field, b. Isabell Field c. Scottsboro Municipal Airport.

Air Carrier - Huntsville/Madison Airport.

Railroads

All existing rail lines and spur extensions.

C. Development of Computer Software

A simple software system necessary to display the results of the project objectives was developed in cooperation with the Computer Science Department, Alabama A & M University. The program was structured so as to have the following capabilities:

- 1) Data Storage (Files - 1, 2, 3, . . . n)
- 2) Data Retrieval (Data Sampling Option)
- 3) Update Capability

The interactive component is such that a user desiring information from this system has only to follow simple steps, e.g.:

Step 1 - Determine desired information.

Step 2 - Determine the grid coordinates of area of interest.

Step 3 - Determine from the file information sheet (Fig. 3) the location of desired data.

Step 4 - Punch the file and grid coordinates on a computer card (Fig. 4).

Step 5 - Place card in the preassemble job deck and read into the computer. In a matter of seconds the output will be printed.

D. Encoding the Data

Concurrent with the development of the computer software was the encoding of the raw data onto computer cards. Three methods of encoding were investigated (Fig. 5) - (1) Manual Encoding, (2) 29E Telereadex with Film Reading and Digitizing and (3) Graphic Tablets. A brief discussion of each method follows and a comparison of these methods is discussed in a later chapter.

**FILE INFORMATION SHEET
TRANSPORTATIONAL ARTERIES
FOR THE
TARCOG AREA**

TAPE: 203

	DISPLAYED
FILE - 1 HIGHWAYS	AS
PRINCIPAL ARTERIAL	1
MINOR ARTERIAL	2
MAJOR COLLECTOR	3
 FILE - 2 RAILROADS & WATERWAYS	
RAILROADS	0
WATERWAYS	4
 FILE - 3 AIRPORTS & DOCKS FACILITIES	
AIRPORTS	
BASIC UTILITY	6
GENERAL UTILITY	7
BASIC TRANSPORT	8
AIR CARRIER	9
DOCK FACILITIES	5

FIGURE 3. File Information Sheet

[illegible]

10

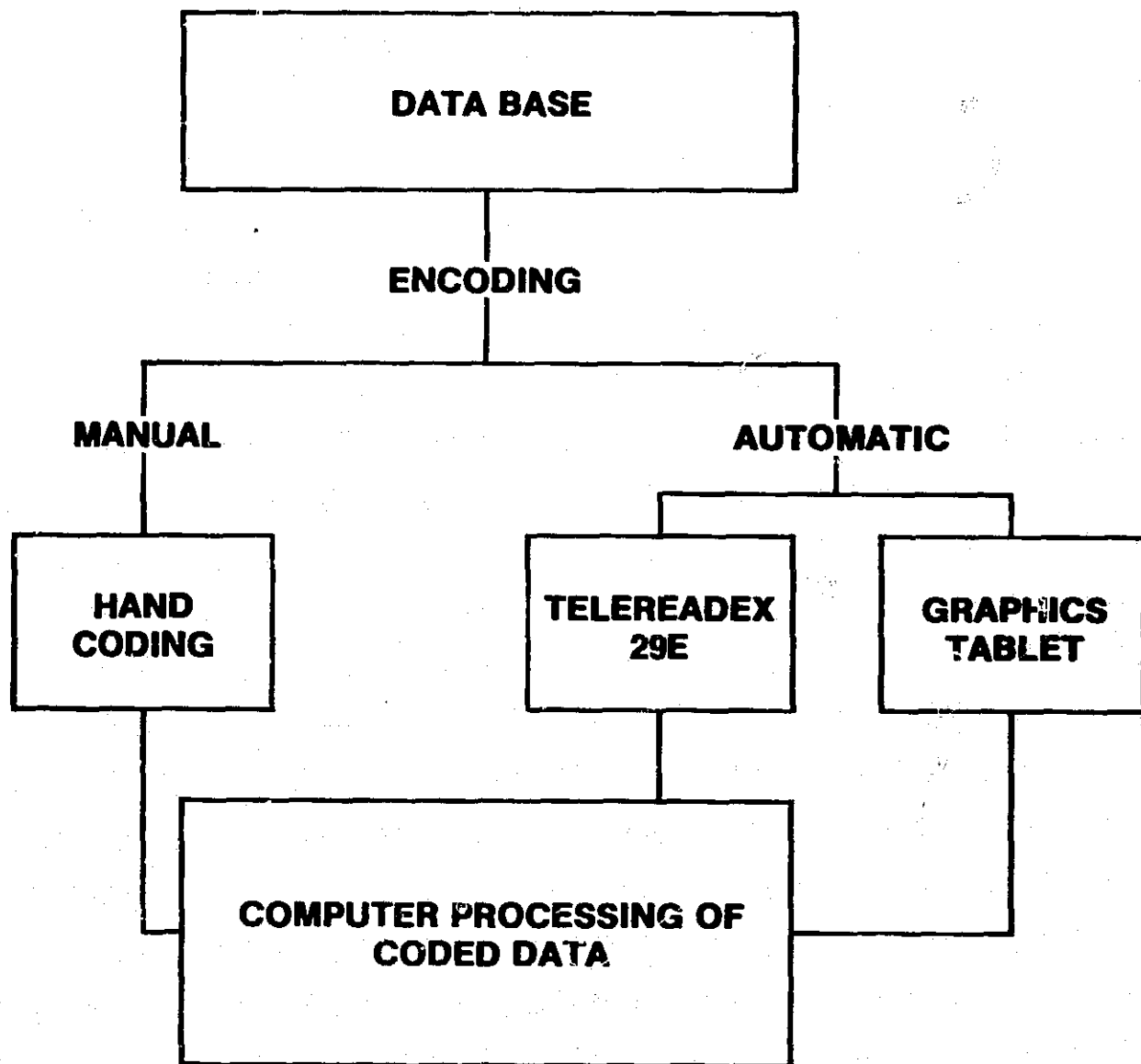


FIGURE 5. Methods of Encoding

Manual Encoding - This method of encoding involved hand coding of the raw data onto coding sheets and the transference of that information to computer cards for processing. The 4-kilometer square U. T. M. grided maps were fastened to the surface of a drafting table and the information was extracted by line and column coordinates. Each data sheet was treated as a "line" and the numbered columns on the sheet corresponded to the east/west columns on the map (Fig. 6). All of the data for the TARCOG area is contained in the first 77 columns of 47 sheets.

29E Telereadex With The Film Reading and Digitizing System - The same raw data used in the manual method was used in every case. Due to the size of the maps on which the raw data was contained, the maps had to be photographed and processed into 35 mm single frame film. Numeric characters were used to represent the different types of information being encoded. The configuration of this system was such that only single number characters were recognized.

The film was mounted on a projection plate and simultaneously projected onto the viewing plate. The viewing plate is a 71 cm by 71 cm metal plate with an opaque photowhite finish; providing high contrast images. Two orthogonal wires on the viewing screen, one on the horizontal axis and the other on the vertical axis, were used to locate the information. To determine the coordinate position of information, the horizontal wire was positioned at the base of the grid and the vertical wire was positioned at the center of the grid. The sequential numbers of each grid was determined by the counting system in the Telereadex. The movement of the wires was controlled by the hand-wheels at the base of the screen. The Telereadex unit was the counter, coordinate system and the digits used to locate and represent the type of information on the film. Digits changed as the type of information changed; but the counter and coordinates changed with the punching of cards and the

ROW _____

Card Col	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27

Card Col	28	29	30	31	32	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48	49	50	51	52	53	54

Card Col	55	56	57	58	59	60	61	62	63	64	65	66	67	68	69	70	71	72	73	74	75	76	77	78	79	80	

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FIGURE 6. Coding Sheet

movement of the wires. A key punch machine is connected to the Telereadex. A card was punched by pressing the foot pedal connected to the Telereadex. Once the pedal was pressed, all of the information displayed on the Telereadex is punched onto a card. One card was used for each grid and only one type of information could be recorded for each grid. Three separate decks of cards were punched: (1) highways, (2) railroads and waterways and (3) airports and dock facilities.

Graphics Tablet With Computer Display Terminal - The Graphic Tablet inputs graphic data into the computer through the computer display terminal. The Tektronix 4015-1 Graphics Tablet is made up of the writing surface, a pen, a power module and the tablet control card connected to the terminal display.

The basic function of the Graphics Tablet is to convert the position of the pen on the tablet surface to a corresponding digital position on the display terminal. To input data, the tablet is made ready by a three-character command string and positioning the pen on the tablet. Data input may be continuous or one point at a time. The Graphics Tablet responds to the pen when the pen is within 3 mm of the surface of the tablet.

The Tektronix 4015-1 Graphics Tablet was used to capture and store the transportation information on computer tape by the computer processors. Each county with its grids were outlined on the tablet and simultaneously shown on the display terminal. When the desired information was drawn in, the computer was instructed to store that information on tape. Additional information could be added to the file by instructing the computer to reprint the file on the screen and entering more information.

Highways, railroads, waterways, airports and dock facilities were input for each county. A user can obtain the information by instructing the computer to display the information on any class from any county.

E. Computer Processing of Data

In the instance where the manual or Telereadex 29E System is used, the information is punched onto computer cards. Once the data is in card form it was ready to be processed for storage and retrieval. Using the prescribed software the information was processed and stored in three files for later retrieval and updating (Table 2). Additional information over the same area can be stored on the data tape without altering existing programs or files.

Table 2. Information Stored From TARCOD Area

File Information Sheet	
<u>Type of Data</u>	<u>File</u>
<u>Highways</u>	1
Principal Arterials	
Minor Arterials	
Major Collectors	
<u>Railroads</u>	2
<u>Waterways</u>	2
<u>Dock Facilities</u>	3
<u>Airports</u>	3
Basic Utility	
General Utility	
Basic Transport	
Air Carrier	

CHAPTER III

DIGITIZATION OF TARCOG AREA

Much of the work required in the digitization of the TARCOG area has been discussed in the previous chapters. The discussion here will be limited to the actual output of the system. The output generated as a result of using either the manual or Telereadex 29E System is the same and as such will be discussed without reference to either system. The output from the Digital Tablets is quite different and will be discussed separately at the end of this chapter.

The data appears to be distorted in the north/south direction, this is due solely to the hardware configuration. The alpha-numeric characters for the computer printer have a width-to-length ratio of about 1:1.2. Each character represents a 4-kilometer square surface on the ground. Data from file - 1 of the data tape is presented in Fig. 7, a map of the raw data over the same area appears in Fig. 8. In the instances where two or more highways appeared in a grid cell, the cell was assigned the code of the highway having the largest transport capability. Information with respect to the location of railroads and navigable waterways is found on file - 2 and is displayed in Fig. 9, accompanied by the raw data in Fig. 10. Airports and dock facilities were stored on file - 3 and appears in Fig. 11 with a map of raw data in Fig. 12.

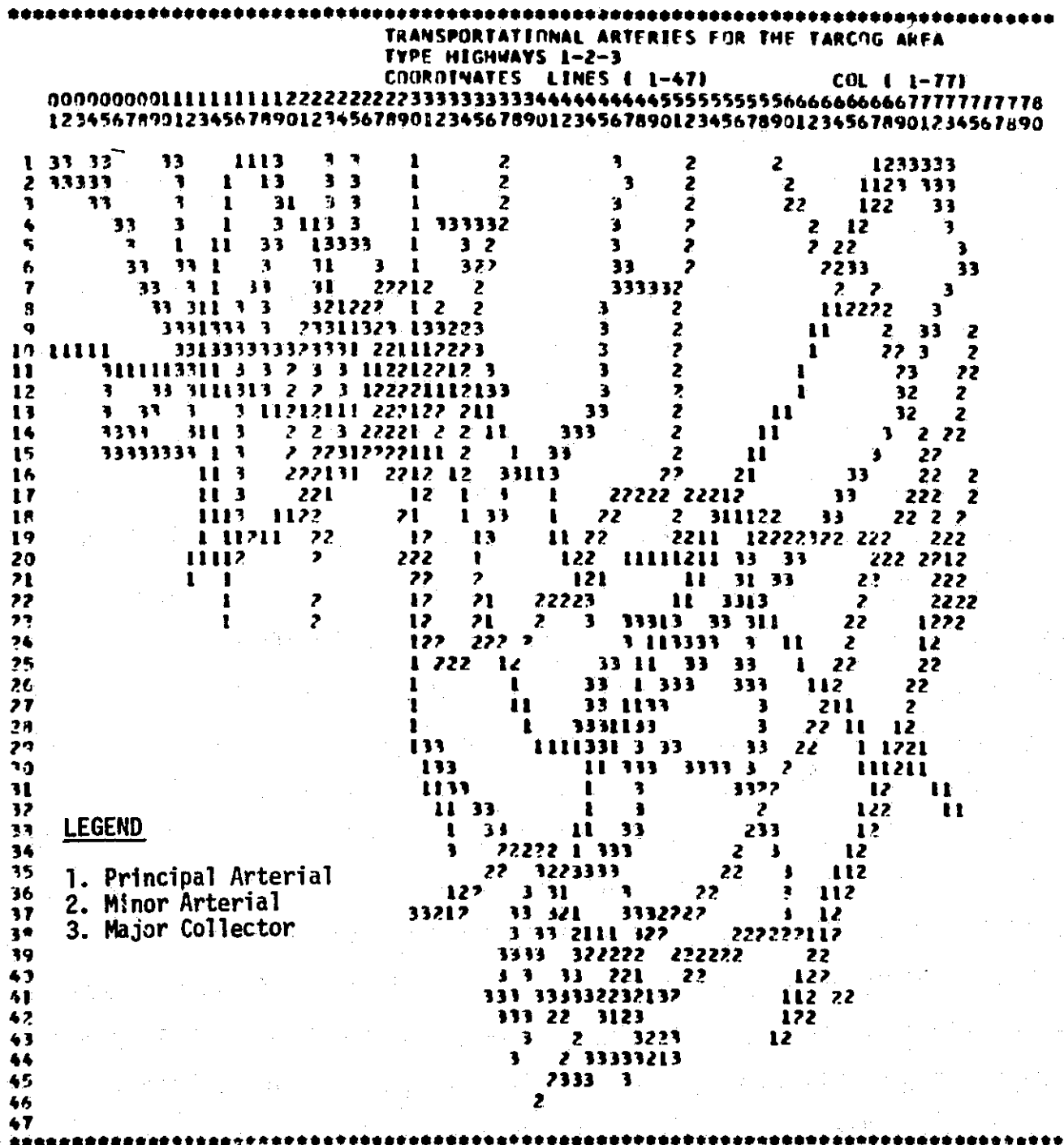


Fig. 7. File 1. Highways within TARCOC area.

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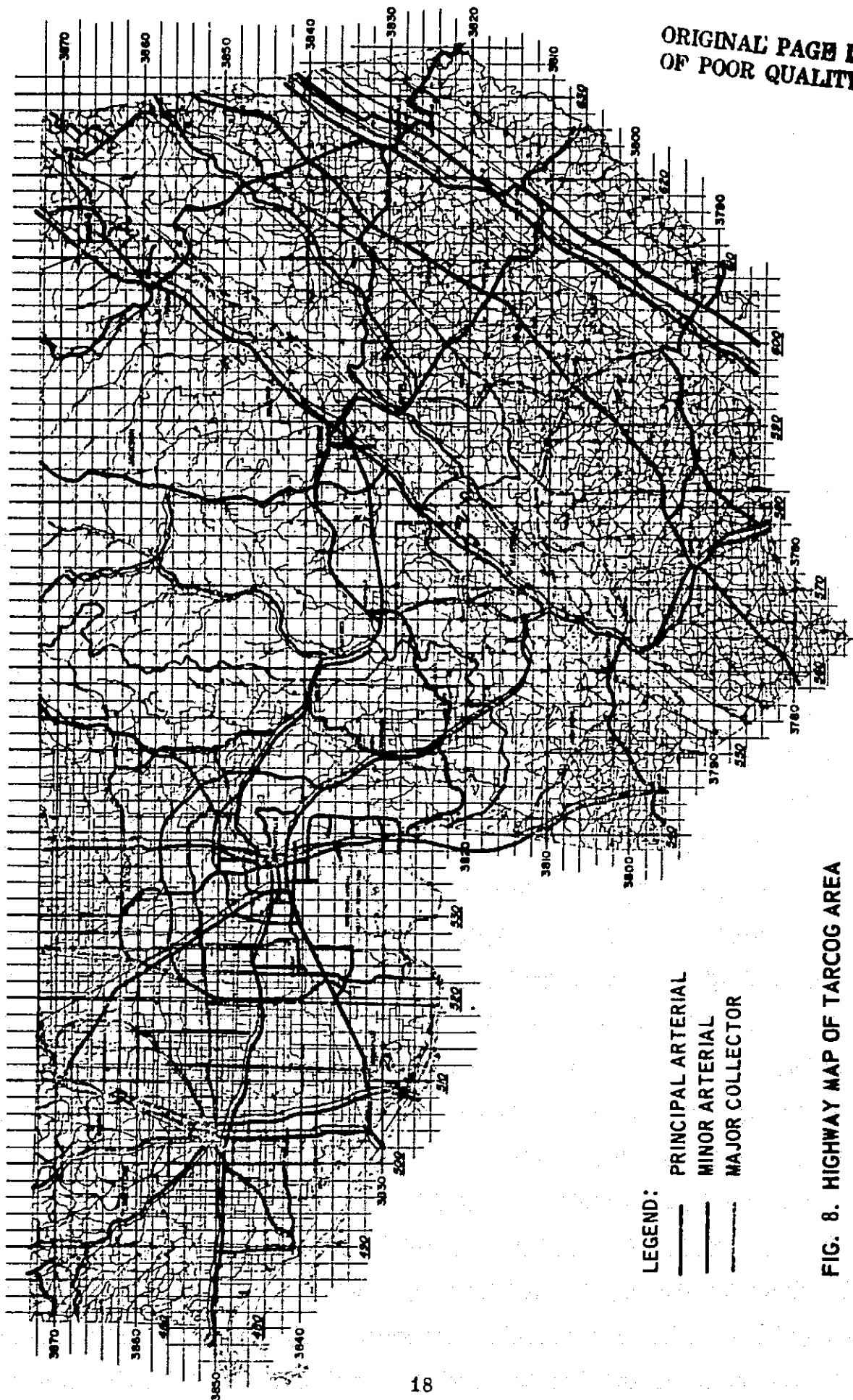


FIG. 8. HIGHWAY MAP OF TARCOG AREA

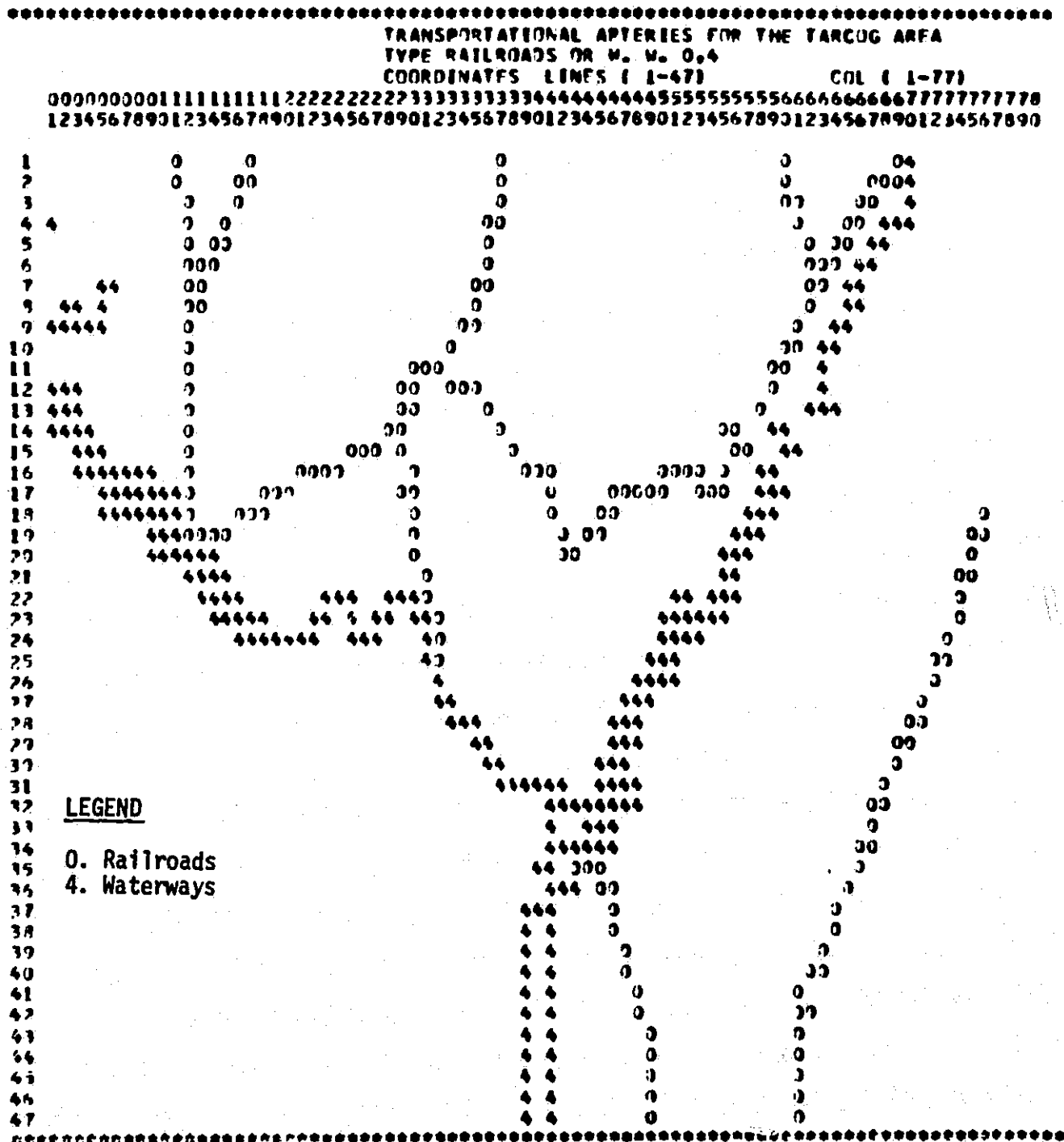
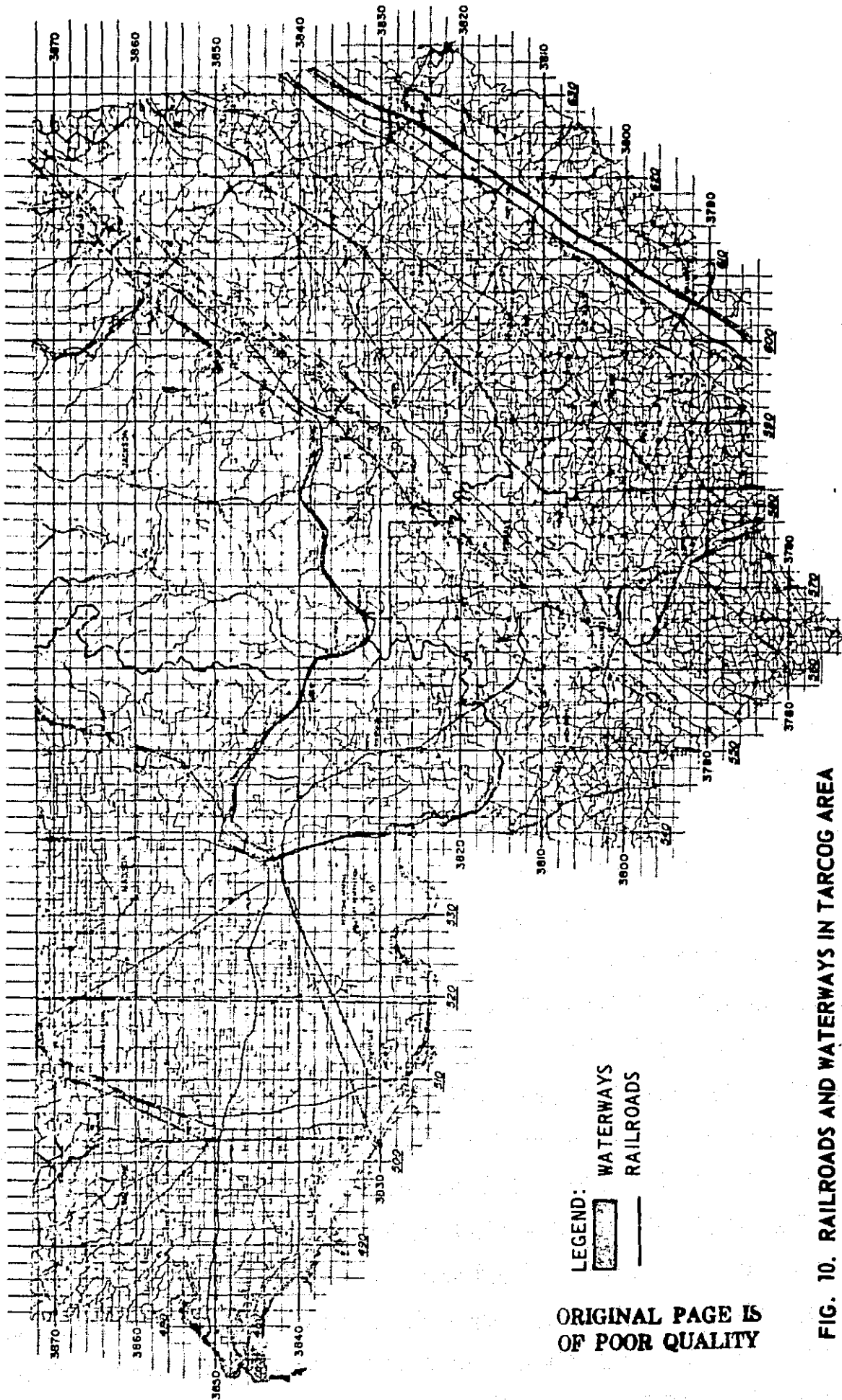


Fig. 9. File 2. Railroads and Waterways in TARCUG area.



LEGEND:
WATERWAYS
RAILROADS

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FIG. 10. RAILROADS AND WATERWAYS IN TARCOG AREA

 TRANSPORTATIONAL ARTERIES FOR THE TARGOG AREA
 TYPE AIRPORTS OR DOCKS 5-6-7-8-9
 COORDINATES LINES (1-47) COL (1-77)
 000000000111111111222222222333333333444444444555555555666666666777777777
 1234567890123456789012345678901234567890123456789012345678901234567890

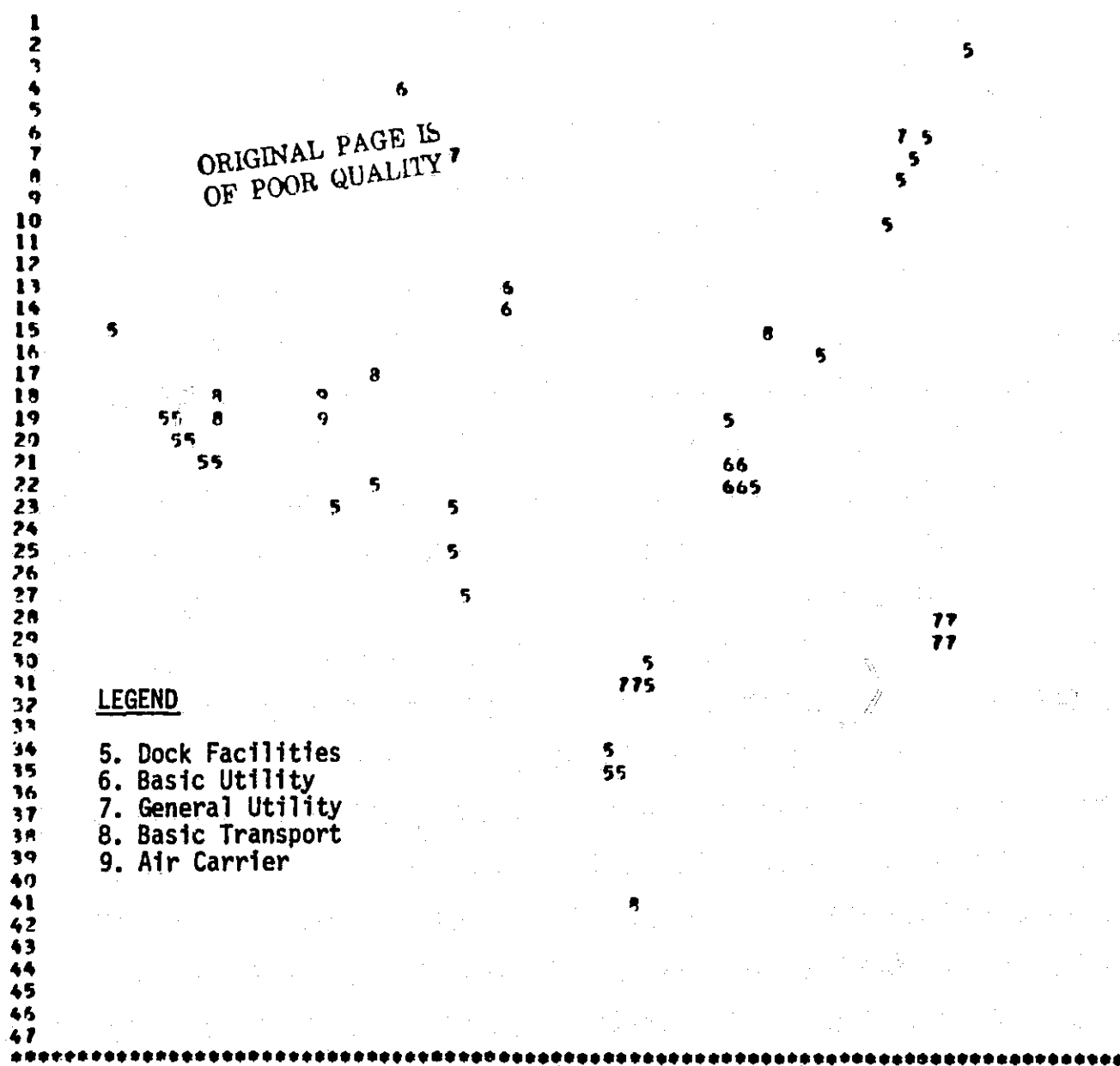


Fig. 11. Airport and dock facilities within TARGOG area.

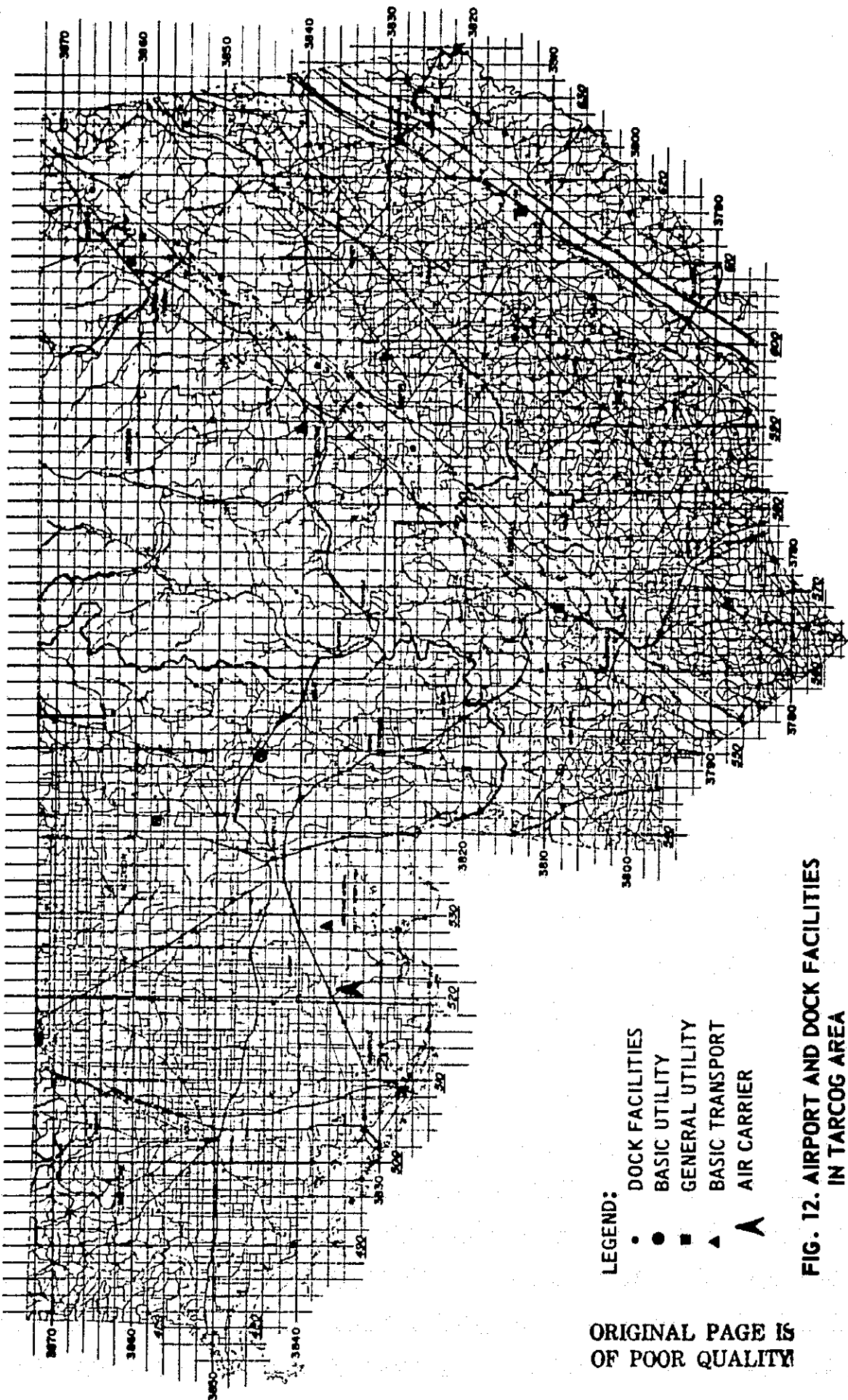


FIG. 12. AIRPORT AND DOCK FACILITIES
IN TARGOG AREA

The processing program was structured such that a user would be able to examine a subset of the data anywhere in a file. This is illustrated in Fig. 13, 14 and 15 where the grid cell coordinates of the areas of interest are punched onto computer cards and fed into the computer. The illustrations show only the information from file - 1; however, the same options apply to the other files.

```

*****
TRANSPORTATIONAL ARTERIES FOR THE TARCOC AREA
TYPE HIGHWAYS 1-2-3
COORDINATES LINES ( 5-25)          CNL (20-40)
0000000001111111112222222233333333444444445555555566666666777777778
1234567890123456789012345678901234567890123456789012345678901234567890

1
2
3
4
5      13333   1   3 2
6      31   3 1 322
7      31   22212  2
8      321222  1 2  2
9      23311323 133223
10     323331 221112223
11     2 3 3 112212212 3
12     2 2 3 122221112133
13     212111 222122 211
14     2 2 3 22221 2 2 11
15     2 22312222111 2  1
16     222131 2212 12 3311
17     221      12  1  3
18     122      21  1 33
19     22      12  13
20     2      222  1
21     22      2
22     2      12  21  2
23     2      12  21  2
24     122  222  2
25     1 22  12
*****

```

Fig. 13. Huntsville-Madison County area.

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TRANSPORTATIONAL ARTERIES WITH THE TARGO AREA
TYPE HIGHWAYS 1-2-3

COORDINATES LINES (1-20)

CM (1-20)

0000000001111111112222222223333333334444444445555555556666666667777777778
1234567890123456789012345678901234567890123456789012345678901234567890

1 33 33 33 1113
2 33333 3 1 13
3 33 3 1 31
4 33 3 1 3
5 3 1 11 33
6 33 33 1 3
7 33 3 1 33
8 33 311 3 3
9 3331333 3
10 11111 3313333333
11 3111113311 3 3 2
12 3 33 3111313 2
13 3 33 3 3 112
14 3333 311 3 2
15 33333333 1 3 2
16 11 3 2
17 11 3
18 1113 11
19 1 11211
20 11112

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Fig. 14. Athens-Limestone County area.

The output from the Graphics Tablet with the Computer Display Terminal is presented in Figures 16 and 17. Due to the line drawing configuration of this system the symbol for each class was changed. The size of the tablet, 4953 (28 cm x 28 cm), prevented the use of the areawise map. Therefore, the information was input into the system on a county by county basis. It should be noted here that there are larger tablets on the market such as the 4954 Graphic Tablet (100 cm x 75 cm). Specific input commands and processing operations are available in the Tektrenex, 4953/4954 Graphic Table, Instruction Manual.

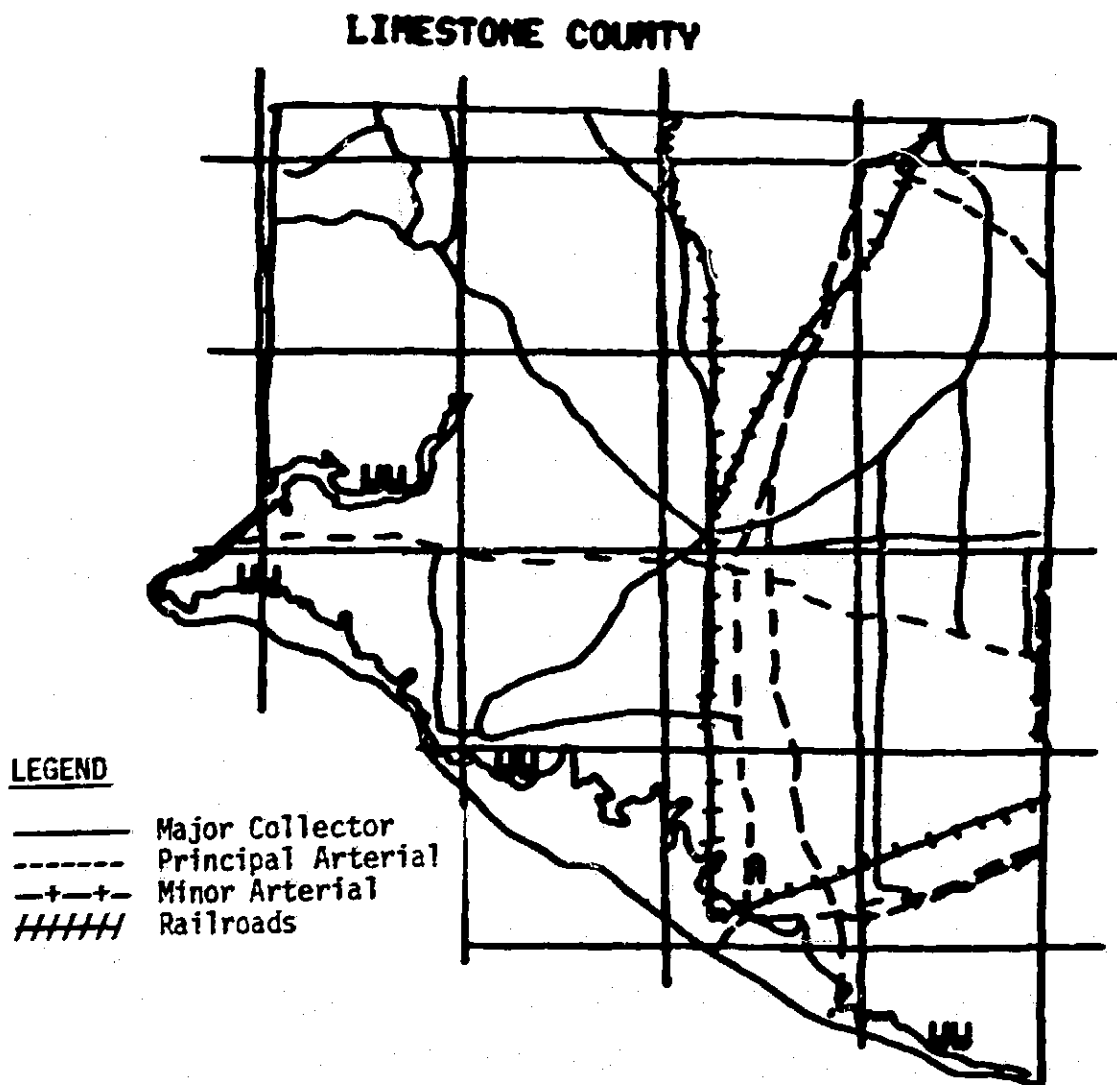


Fig. 16. Highways within Limestone County

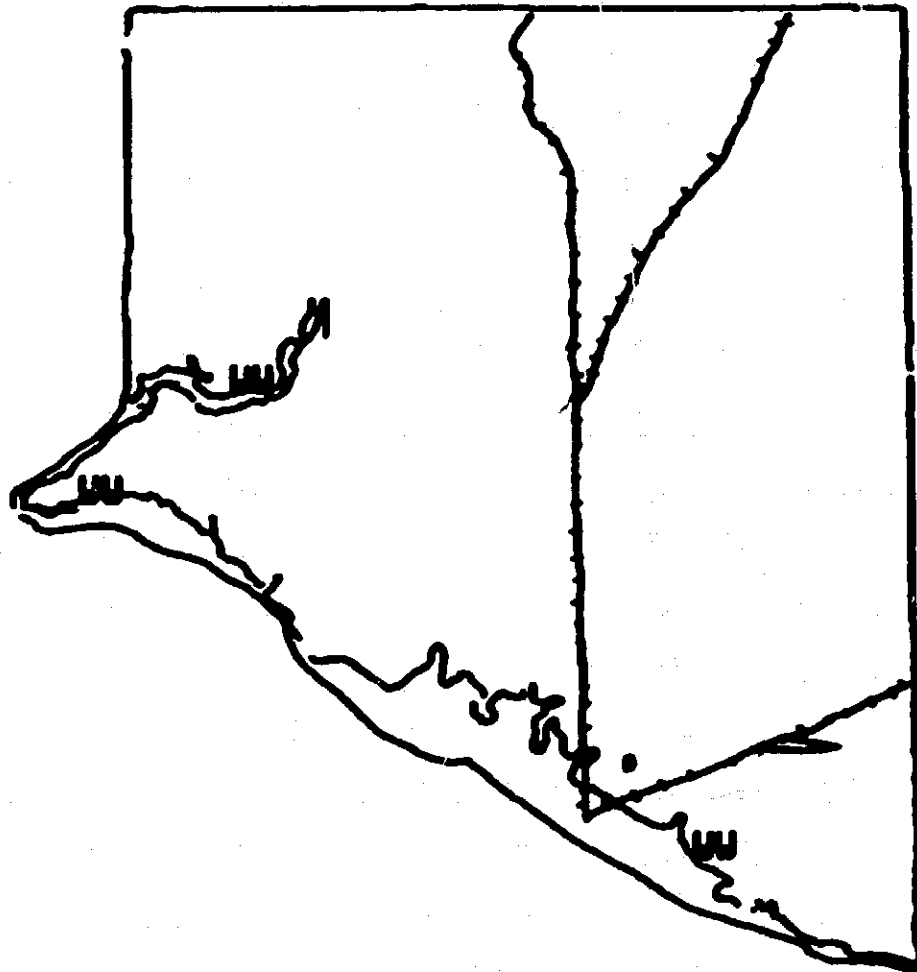


Fig. 17. Railroads and Waterways in Limestone County.

CHAPTER IV

EVALUATION OF DIGITIZING METHODOLOGIES

Once the data has been collected and an acceptable classification has been developed, the investigator is confronted with the problem of which system is most efficient for his use. The answer to that question is not a simple one, for it is dependent on several variables such as: data type; intensity of data; projected use of data; format requirements of digitized output; and most of all, the resource environment in which the investigator is placed.

An effort was made to determine the efficiency of the digitizing methods available for encoding the information on the TARCOG area. The results presented are only applicable to equipment similar to the type of equipment tested with similar types of data. The three methodologies were as follows: (1) Manual Encoding; (2) Telereadex 29E with the Film Reading and Digitizing System and (3) Graphics Tablet with Computer Display Terminal. The time required to encode the various classes using these devices are presented in Table 3.

Table 3. Times Required for Digitization of TARCOG Area

Digitized Classes	Methods of Digitizing		
	Manual	29E	Tablets
Highways	188 min	195 min	42
Railroads and Waterways	95 min	245 min	19
Airports and Dock Facilities	37 min	255 min	17

The times appearing are the totals of time when the actual encoding was being done. Constant interruptions by either equipment failures or time-sharing constraints made this approach necessary. The encoding began in the early stages of the research and continued stop-and-go up to the writing of this report. At first glance the manual method appears to be the most efficient. It has a decided advantage over the Telereadex 29E system in both time and the amount of preprocessing of raw data. The differences in the amount of time required are largely due to the type and intensity of the data, with intensity of data being the major factor. Looking at the differences in time required to digitize highways and differences in time required to digitize airports and dock facilities, the former is much less than the latter. There were fewer data points for airports and dock facilities than for highways. The configuration of the Telereadex 29E does not allow for the passing of grid cells that were empty without losing special distribution; whereas the manual method allows the operator to skip over those cells which did not contain pertinent information.

The Digital Tablets required less time than the other methods. Once the operator has access to the program, he simply draws in the information which is transferred directly to the computer tape. These types of digitizing systems have numerous advantages over the aforementioned systems. It may be the best system for this type of encoding. It would certainly be worth the effort and cost if ARIS could purchase this type of system.

The resource environment, more than any other factor, will determine the feasibility of any of the methodologies. The equipment discussed here can be obtained at a cost which is out of reach for those institutions or agencies operating with limited funds.

CHAPTER V

SUMMARY AND CONCLUSIONS

With respect to the previous discussions and illustrations the following statements can be made:

- 1) A method for digitizing and storing information from a U. T. M. grid cell base has been developed and tested. It is believed that this system is compatible with ARIS data system.
- 2) The transportation arteries within the TARCOG area have been digitized and processed in a manner the data can be stored, retrieved and updated with minimum program manipulations.
- 3) A brief examination of three methods indicate that for limited amounts of data the manual method of encoding may be most feasible. The graphics input system would be the best approach to take when one considers the overall goal and objectives of the ARIS system.
- 4) The accuracy of the computerized maps could be improved by using 1-kilometer square grided maps. This reduction would increase both the accuracy and the amount of data input into the system.